
7 QUALITY CONTROL

Contractor Personnel

- QCP Manager**
- QCP Site Manager**
- Certified Concrete Technician**

Facilities and Testing Equipment

Process Control of Aggregates

- Gradation**
- Water Absorption**
- Bulk Specific Gravity (SSD)**

Process Control of Concrete

- Slump**
- Air Content and Unit Weight**
- Water/Cementitious Ratio**
- Compressive Strength**

Process Control of Reinforcing Steel

Response to Test Results

- Slump**
- Water Absorption**
- Unit Weight**
- Water/Cementitious Ratio**
- Air Content**

Documentation

Quality Control Plan

QCP Approval

QCP Addenda

CHAPTER SEVEN:

QUALITY CONTROL

The foundation for a successful Quality Assurance program is the control maintained by the Contractor to assure that all materials submitted for acceptance conform to the contract requirements. To accomplish this it is imperative that the Contractor have a functional Quality Control Plan (QCP) to keep the process in control, quickly determine when the process goes out of control, and respond adequately to bring the process back into control.

This chapter includes the minimum requirements for maintaining quality control during production of QC/QA superstructure concrete. Acceptance test results by INDOT will be shared with the Contractor; however, results of these tests should not be used for quality control purposes.

CONTRACTOR PERSONNEL

The Contractor personnel required to provide quality control on a QC/QA superstructure concrete project include a QCP Manager, QCP Site Manager, and a Certified Technician. One quality control person may perform the duties of more than one position.

QCP Manager

The QCP Manager is responsible for the overall administration of the QCP on the project.

QCP Site Manager

The QCP Site Manager is responsible for the execution of the QCP and is the liaison with the PE/PS. This person is often the QCP Manager also and is at the plant or project during production.

Certified Concrete Technician

A Certified Concrete Technician is a Contractor, Producer, or Consultant employee who has been certified by INDOT. The technician is required to be at the plant for the trial batch demonstration, and be at the plant or at the site of work at the point of placement until placement and finishing are complete. The technician is required to supervise all sampling and testing for quality control. An American Concrete Institute (ACI) certified concrete field testing technician, grade I, is required to perform all sampling and testing for quality control.

FACILITIES AND TESTING EQUIPMENT

The Contractor is required to have a container filled with water saturated with calcium hydroxide at the work site for initial curing of compressive strength specimens. Also, an easily accessible means of obtaining concrete samples at the point of placement and transporting them off of the bridge deck for testing is required for INDOT use.

The Contractor's equipment furnished for testing is required to be properly calibrated within the limits designated in the applicable test method, except as such requirements may be modified in the Standard Specifications. A record of all equipment calibration or verification results is required to be maintained for all applicable equipment listed in Figure 7.1. The procedures and forms for calibration are included in Appendix C.

| Equipment | Requirements | Minimum Frequency | Procedure |
|----------------------|--------------------------|-------------------|----------------------------------|
| Air Meter | Calibration | 3 months | AASHTO T 152 or ASTM C 173 |
| Balances | Verification | 12 months | ITM 910 |
| Sieves | Check Physical Condition | 6 months | ITM 902 |
| Slump Cones | Verifying Dimensions | 12 months | ITM 911 |
| Testing Machine | Verification | 12 months | AASHTO T 67 |
| Thermometers | Verification | 6 months | ITM 909 |
| Unit Weight Measures | Calibration | 12 months | AASHTO T 121 |

FIGURE 7.1 - EQUIPMENT CALIBRATION REQUIREMENTS

PROCESS CONTROL OF AGGREGATES

The Contractor is required to monitor gradation, water absorption, and Bulk Specific Gravity Saturated Surface Dry (SSD) of the aggregates to verify compliance with the properties of the aggregates used at the time of the Trial Batch Demonstration.

Gradation

A copy of the gradation control charts are required to be obtained from the Certified Aggregate Producer within seven days of concrete placement operations. The charts shall represent production and load-out test results for gradation tests since the Certified Aggregate Producer was certified, but not more than the 30 most recent results. In lieu of obtaining control charts from the Certified Aggregate Producer, gradation tests of the aggregates stockpiled at the plant may be performed within seven days of concrete placement operation. Stockpile samples should be sampled in accordance with ITM 207, reduced in size by AASHTO T 248, and tested in accordance with AASHTO T 27.

The gradation tests are used to verify that 100 percent of the coarse aggregate passes the 1 in. sieve. Also, the gradation tests shall verify that the mathematically combined amount passing the No. 200 sieve of fine and coarse aggregates is from 0.0 to 2.0 percent for sand and gravel and from 0.0 to 2.5 percent for sand and stone or slag. The proportions of fine and coarse aggregate shall be in accordance with the concrete mix design.

Water Absorption

The water absorption test is required to be conducted on the fine and coarse aggregates in accordance with AASHTO T 84 and AASHTO T 85, respectively. The tests are required within ten days prior to concrete placement operations unless the aggregate is from a captive stockpile.

Bulk Specific Gravity (SSD)

The bulk specific gravity (SSD) tests are required to be conducted on the fine and coarse aggregates in accordance with AASHTO T84 and AASHTO T 85, respectively. For coarse aggregates, both procedures 8.1 and 8.2 of AASHTO T 85 are required. The tests are required within ten days prior to concrete placement operations unless the aggregate is from a captive stockpile.

PROCESS CONTROL OF CONCRETE

The Contractor is required to test the slump, air content and unit weight, water/cementitious ratio, and compressive strength for process control of the concrete during production. Samples are obtained from the site of work at the point of placement.

Slump

The slump test is required to be conducted in accordance with AASHTO T 119. The minimum frequency of tests is one slump test for each subplot; however, the slump test is required on the concrete mix from the first truck for each day of production.

Air Content and Unit Weight

The air content test is required to be conducted in accordance with AASHTO T 152 or AASHTO T 196 (Slag), and the unit weight test conducted in accordance with AASHTO T 121. The minimum frequency of tests is one test for each property for each subplot; however, the air content and unit weight are required to be determined on the concrete mix from the first truck for each day of production. An additional air content and unit weight determination shall be made if there is a change in production, delivery, or placement.

Water/Cementitious Ratio

The water/cementitious ratio is required to be determined in accordance with ITM 403 at a frequency of one determination for each day of concrete placement operations.

Compressive Strength

The compressive strength is required to be determined in accordance with AASHTO T 22 at a frequency of one set of two cylinders tested at 28 days for each subplot. Specimens shall be made and cured in accordance with AASHTO T 23 except that the initial curing shall be done by completely submerging the cylinders in water saturated with calcium hydroxide at a temperature of 60 to 80°F for no less than 16 nor more than 48 hours. Transportation of the cylinders to the laboratory shall not exceed four hours.

PROCESS CONTROL OF REINFORCING STEEL

The depth of concrete over the uppermost bar of the top mat of reinforcing steel is required to be measured at a frequency designated in the QCP. Measurements are required to be obtained as soon as the concrete is placed and struck off, and while still plastic.

A summary of the minimum testing frequencies required for process control of the aggregates, concrete mixture, and depth of cover of concrete over reinforcing steel is shown in Figure 7.2.

| MINIMUM TESTING FREQUENCIES | | | | |
|--------------------------------|-------------------------------------|------------------------------------|-------------|----------|
| Material & Concrete Properties | Within 7 days of Concrete Placement | First Truck Each Day of Production | Each Sublot | Each Day |
| CA Bulk (SSD) | X | | | |
| CA Absorption | X | | | |
| CA Gradation | X* | | | |
| FA Bulk (SSD) | X | | | |
| FA Absorption | X | | | |
| FA Gradation | X* | | | |
| W/(C+P+SF) | | | | X |
| Slump | | X | X | |
| Air Content | | X | X | |
| Unit Weight | | X | X | |
| 7-Day Strength | | | X | |
| 28-Day Strength | | | X | |
| Depth of Cover ** | | | | |

* Conducted in lieu of obtaining control charts from the Certified Aggregate Producer

** Frequency as stated in QCP

FIGURE 7.2

RESPONSE TO TEST RESULTS

The Contractor is required to take corrective action when quality control test results exceed the established limits. The corrective actions shall be designated in the QCP. As a minimum, corrective actions are required for the slump, air content, unit weight, water/cementitious ratio, water absorption, and depth of cover. Documentation of corrective actions are required.

Slump

Corrective action for slump should be taken when quality control limits are exceeded, so that test values are always maintained between 4-7 1/2 inches for concrete with HRWR, 2-4 1/4 inches for superelevated bridge decks, or the required limits in the Special Provisions.

Water Absorption

Corrective action is required when the absorption value for a particular size of aggregate differs from the mix design value by more than 0.5 percent. As a minimum, the absorption for the source, shall be investigated and an absorption percent determined.

Bulk Specific Gravity (SSD)

Corrective action is required when the bulk specific gravity (SSD) of the fine aggregate differs from the mixture design value by more than 0.056 or the bulk specific gravity (SSD) of the coarse aggregate differs from the mixture design value by more than 0.032.

Unit Weight

Corrective action is required when the unit weight varies by more than $\pm 1 \text{ lb/ft}^3$ from the predicted value for the air content measured, not to exceed a unit weight representing a water/cementitious ratio of 0.420.

Water/Cementitious Ratio

Corrective action for water/cementitious ratio should be taken when the quality control limits are exceeded, so that there is confidence that the process is centered about the mix design value. Test values should always be less than 0.420 for concrete without silica fume, and always between 0.370 and 0.420 for concrete containing silica fume.

Air Content

Corrective action for air content should be taken when the quality control limits are exceeded, so that subplot test values are always maintained from 4.0 to 10.0 percent. Lot test values shall be maintained within 5.7-8.9 percent for concrete without silica fume and within 5.3-8.9 percent for concrete with silica fume.

DOCUMENTATION

The test results for quality control are required to be maintained by the Contractor for a period of three years upon completion of the contract. The records, either electronic and/or hard copies, shall be maintained at a readily accessible location for review by INDOT at any time. As a minimum the documentation shall include test results for the aggregate tests, mixture tests, and depth of cover of concrete over reinforcing steel measurements.

QUALITY CONTROL PLAN

The Contractor is required to submit a QCP that is contract specific and states how the process control of materials, equipment, and operations shall be maintained. As a minimum, the QCP shall include the following information for each project.

1. The name, telephone number, duties, and employer of all quality control personnel necessary to implement the QCP. The minimum number of quality control personnel shall be a QCP Manager, QCP Site Manager, and Quality Control Technician.
2. The location of the testing facility to be used for the determination of the compressive strength of concrete.
3. A list of the testing equipment proposed for process control testing, and the test methods and frequency of calibration and verification of the equipment.
4. The source, transportation, handling, and storage procedures, if applicable, for the materials to be used in the superstructure concrete.
5. The procedure for monitoring the aggregate gradation, water absorption, and Bulk Specific Gravity (SSD) to verify compliance with the properties of the aggregates used at the time of the trial batch demonstration(s).
6. The procedures, location, and type of equipment to be utilized during the trial batch demonstration(s).
7. The techniques and controls of the concrete batching operations. A description of the plant, including the capacity and intended batch size, and the methods and sequence by which the plant produces a batch shall be included. The plant shall have been inspected in accordance with ITM 405.

The initial and routine equipment checks, including those performed on scales, water meters, and admixture dispensers, mixing equipment, and agitators, if applicable, shall be included. All material checks, including frequencies of testing, shall be identified. The methods to monitor ingredients used, and the record of each batch shall be included.

8. The location, procedures, and frequency for sampling and testing the concrete mix for slump, air content and unit weight, water/cementitious ratio, and compressive strength.

9. The procedure and frequency for monitoring the depth of concrete over the uppermost bar of the top mat of reinforcing steel.
10. The response to process control tests not within the established requirements.
11. The equipment and methods for delivery of the concrete. The description or plan drawing of the traffic patterns for delivery of the concrete mix to the site of work shall be included.
12. The procedures for placement of the concrete to include as a minimum the placing sequence, identification of the placing equipment, and a description of the pumping procedures, if applicable.
13. The methods for finishing, texturing, and curing concrete. The description and identification of the equipment shall be included.
14. The procedure for determining when the forms, falsework, and centering may be removed. The minimum frequency of samples for determination of removal shall be two cylinders or two beams.

QCP Approval

The QCP is required to be submitted to the PE/PS for review at least 15 calendar days prior to commencing concrete operations. The Contractor shall sign and date the QCP at the time it is submitted to the PE/PS. The PE/PS will sign and date the QCP if the contents of the QCP are in compliance with the above-noted requirements. Concrete operations shall not begin before the QCP has been accepted and a successful trial batch demonstration completed. Concrete mix designs and trial batch demonstrations may be submitted for approval prior to the submittal of the QCP.

QCP Addenda

The QCP shall be maintained to reflect the current status of the operations, and revisions are required to be provided in writing prior to initiating the change. The change shall not be implemented until the revision has been accepted; however, traffic patterns for delivery of the concrete mix to the site of work may be adjusted for unanticipated conditions without an addendum to the QCP.